EMPYEMA IN CHILDREN

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by

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E M P Y E M A I N C H I L D R E N.

Empyema or pus in the pleural cavity is a disease which always has taxed, and probably more or less always will tax the diagnostic powers of the clinician to their utmost. The condition was well known to the ancients, and Hippocrates the Father of all Medicine, has given it considerable attention and has laid down many maxims accordingly. Though its recognition dates from such an early period, and one has only to look at the magnitude of the literature on the subject to realize how enormous the amount of observation, care and attention that has been bestowed upon empyema; yet despite it all, one is constantly being confronted with a case where it is impossible without actually exploring the pleural cavity itself, to make a conclusive and final diagnosis. This holds more perhaps in children than in adults, since the physical signs in the thorax of the child are acknowledged to be more difficult of interpretation than in that of the adult. The observations in this paper have

been conducted upon children up to fourteen years of age, the usual limit of admission to a Children's Hospital. I have chosen children for investigation, since the results of early diagnosis and adequate treatment in the child are always much more satisfactory and encouraging than in the adult.

Frequency.

Taking the admissions of the East London Hospital for Children, Shadwell, for the year 1903, 2.8% were diagnosed as empyemata which treatment subsequently corroborated. This is a much higher percentage than one finds in a General Hospital and the reason is found in that children are so much more prone to lung affections following the specific fevers, etc., which affections all tend to the establishment of a purulent reaction in the pleura.

Age Incidence:

According to Holt[1] and Koplik,[2] the majority of cases occur under 5 years of age. Blaker,[3] in a series of 81 cases found 34% between 1 and 2 years. Cautley[4] puts it at 45%. From an analysis of 46 cases, I find that 39% occurred below 2 years of age, 5.2% between 2 and 6 years, and 9% above 6 years.

Sex Incidence:

If anything, the preponderance is amongst the males. Simmonds and Hofmokl[5] of Vienna found the males in the ascendant. Blaker's[6] statistics also support this, while Cautley[7] finds it prone to affect either sex almost equally. In my own cases there were more males than females.

Side affected:

In the great majority of cases, one might say almost invariably, the empyema is unilateral. In my series I had two which were bilateral. Cautley[8] in a record of 86 cases, found two with pus in both pleura. Blaker[9] had 9 out of 81 cases. Most observers state that the left side is the more commonly affected, which side is also the more common site for pneumonia, the frequent precursor of empyema.

Etiology:

Empyema has been classified as Primary and Secondary, according as to whether the primary inflammation severe enough to produce a purulent reaction began in the pleura itself, or whether the infection of the pleura was consequent on a focus of disease elsewhere.

The Primary form of the disease is exceedingly rare and many writers are very sceptical as to its existence. There was one case in my series, however, which would seem to come under this class, and which I now append:

S. A boy, aet 7 years and 4 months, was admitted to Hospital on February 3rd, 1904, complaining of pain in the right chest, accompanied by vomiting. The onset occurred two days previously. The symptoms set in quite suddenly and continued up till admission. Patient was moderately nourished. Respiration short and catchy. The face suggested an acute abdominal condition, and the knees were drawn up.

The heart's apex beat was in the 6th left space, ½ inch outside the left nipple line. The lungs presented no abnormality. The abdomen was slightly resistant down the right side. No distension. Examination of the urine was negative. There was a leucocytosis of 28,000. Temperature normal; pulse 90.

The patient remained pretty much in statu quo till the 5th of February, when the abdomen became more distended and the lightest touch elicited severe pain. It was decided to open the abdomen,

as the patient seemed to be sinking. This was done under chloroform, but nothing was found.

The child died on the following day.

P.M. On the right side of thorax, the lower lobe of the right lung was on its posterior aspect separated from the chest wall by 4 to 5 oz. of pus which extended diaphragmatically and between the lobes. The pus was pneumococcal and a culture of the heart's blood gave almost pure pneumococci.

There was no evidence of any lesion elsewhere. No consolidation of the lung substance. No meningeal or peritoneal infection even. The case is of interest in another way, as showing the simulation of an acute abdominal condition by an inflammation of the diaphragmatic surface of the pleura. Also as showing the absence of temperature even in the acute inflammation of the pleura, the only rise occurring just before death.

D'Arcy Power[10] states that the primary form is very rare, sometimes simulating an acute abdominal lesion with sudden onset, with convulsions or vomiting, generally a high temperature from 103°F. to 104°F., respirations short and quick, and of the abdominal type, the organism usually found being the pneumococcus; in fact, corresponding with the above case in every particular, excepting the temperature.

Power[11] estimates the duration of the acute stage from 7-10 days, and then the temperature falls, but never quite to the normal. Cough persists, and wasting, and other concomitant symptoms set in and the disease runs the course of the more common secondary variety.

Holt[12], Koplik and others admit the primary form, but remark on its rarity. Gee[15] on the other hand, states that primary pneumococcic empyema is very common in children and that seldom is empyema preceded by a pneumonia.

In the Secondary variety we may have various antecedents to the disease. Holt puts the number of cases under 5 years of age following pneumonia at 90%. It may follow any of the acute infectious diseases, e.g. scarlet fever, measles, or any disease of a pyemic nature.

In the newly born the pleura may become infected through the raw surface of the divided umbilical cord. It may follow osteomyelitis, suppurative arthritis, and purulent peritonitis. It may result from trauma, though rare, and from necrosis of a rib. An abscess in the thoracic wall may burst internally, and thus give rise to an empyema or we may get extension of mischief from the mediastinum or from a subdiaphragmatic abscess, or even from an abscess in the lung itself.

Bacteriology:

One would naturally conclude from the proximity of the pleura to the lung that any acute lesion of the latter would tend to infect the former. This is undoubtedly the case. In children, pneumonia either lobar or lobular is the almost invariable precursor of empyema, and in consequence the pneumococcus is responsible for the great majority of empyemas; 71% of my series were pneumococcic. This is rather below the percentages of Holt, Netter[13], Goodhart,[14] Blaker, and others, whose statistics are compiled from a much larger number of cases, and hence probably a fairer estimate.

One may also find the staphylococcus or the streptococcus, either alone or in combination with the pneumococcus. There were two staphylococcic empyemas in my series, the one aureus and the other albus.

The streptococcus seldom occurs alone; it is usually found plus the pneumococcus.

Koplik[16] puts this combination at 9% and a similar percentage for the staphylococcus alone.

Blaker[17] reports 3 cases where the streptococcus was the only organism present in the exudate. The staphylococcus plus the pneumococcus is usually found in those empyemas secondary to pneumonias

consequent on a pyemia and staphylococcic abscesses elsewhere.

The pneumococcic streptococcic combination is found after the pneumonia of an infectious disease.

There is one point I should like to emphasize most strongly, viz., that the tubercle bacillus very rarely is a cause of empyema. In all the literature I have read bearing on this point, there has been a remarkable unanimity on the rarity of the tubercle bacillus as a factor in empyema.

Blaker[18] had three cases out of 81, which were confirmed by post mortem examination, showing the presence of tubercle in the lung substance.

Holt[19] says the tubercle bacillus is found more commonly after the 7th year.

Various other organisms have been found, e.g., the Eberth bacillus after typhoid - Phillips[20] reports two cases of empyema in brothers following typhoid abscesses in the lung. Escherich[12] has also noticed the presence of the bacillus coli.

Ashby[22] reports a cure in a case of empyema and peritonitis in which the micrococcus tetragemus was found alone in the peritoneum and along with the pneumococcus in the pleural cavity.

Diagnosis:

An early diagnosis of pus in any region is always important, and none the less so in the case of the pleural cavity.

In a child there are several factors to be taken into consideration in examining the chest which alter to a great extent the physical signs of a pleural effusion common to the adult.

One must bear in mind the extraordinary powers of conduction which the thorax of the child seems to possess, e.g. signs of friction may be almost as well heard on the healthy side as on the side of the lesion. This may be proved by immobilising the affected side when the sounds cease on the healthy side. Cardiac sounds can sometimes be heard quite clearly over the posterior aspect of the thorax in a quite normal healthy chest. The thinness of the chest wall should be taken into consideration. Heavy percussion is to be avoided. Percussion should always be light. A considerable amount of fluid may escape detection if the percussion stroke be unduly heavy and bring out a resonant note from the underlying lung tissue.

I believe, however, that there is more to be gained from the sensation imparted to the finger than from the actual sound of the percussion note.

Another fact which has to be considered is that the whole diagnosis must be founded on the objective alone, as the patient is seldom able to furnish one with any account of symptoms which might be of value.

History:

The history should always be gone into very carefully, as it is sometimes of great aid in establishing a diagnosis. When one gets a history of a pneumonia with a somewhat indifferent crisis, cough, persisting restlessness at night, wasting and general lassitude, breathing becoming more laboured, and tendency to cyanosis, one naturally thinks of empyema. Unfortunately, the onset is often much more insidious, and one gets a vague account of wasting and slight cough, perhaps a tendency to diarrhoea and anorexia, and in only too many instances does the history offer little or no aid to diagnosis. However, in no case should the history be ignored, though care should be taken not to be misled by symptoms which a mother in her anxiety often magnifies beyond a sense of their real importance.

Henoch(23) points out that the history of child taking only one breast may mean that the

child lies on the side which is filled with fluid, in order to give the sound side free play, otherwise the child could not breathe.

Ashby and Wright[24] lay stress on a history of zymotic disease as an aid to diagnosis between pus and a simple fluid effusion, stating that signs of fluid after a zymotic disease are in favour of pus.

Inspection - General:

In a typical case with a fair sized empyema one finds the child suffering from dyspnoea, alae nasi acting slightly, slight cyanosis of the lips, and the lobes of the ears. Eustace Smith[25] describes a "pleuritic look", consisting of a straw-coloured waxy look round the alae nasi and upper lip, and lays considerable stress on it as distinguishing between a pneumonic consolidation where it is not found, and an effusion into the pleural cavity. I have noted it in several of my cases, but it is not diagnostic of pus, as I have seen it quite as often in simple effusions.

Barbour[26] takes note of the pallid countenance and Donkin[27] of the waxy colour as pointing to pus. Goodhart[28] says that pallor and puffiness of the face indicate a large amount of fluid in the pleural cavity.

The fingers and toes, if not actually clubbed often shew a tendency to clubbing. The terminal phalanx of the digit is broadened and also thickened antero-posteriorly. The skin at the root of the nail is smooth, shiny and glossy, usually slightly congested-looking. This fact has been commented on by the ancients, who state that the clubbing may set in fourteen days after the onset of the empyema. This clubbing alone is of no diagnostic value, since chronic pulmonary or congenital heart mischief may give rise to the same condition; but, taken in conjunction with the other physical signs, it may help us to a correct diagnosis.

Lindsay[29] Barbour[30] and Gee[31] also mention it amongst other symptoms.

Thorax: If the amount of fluid be small, there may be absolutely nothing abnormal noticeable beyond slight frequency of respiration. If the effusion be large, then one may notice that the side affected moves little if at all, also that there may be some bulging of the inter-costal spaces. This bulging takes place much earlier in an empyema than in a pleurisy with an equal amount of effusion. West[34] ascribes this to the suppurative inflammation involving the adjacent tissues and thus affecting the nutrition of the intercostal muscles and

so producing the bulging. On the other hand, in simple effusion it is only the long continued pressure which mechanically overcomes the elasticity of the muscle fibres, and causes bulging.

Koplik[33] attaches considerable importance to the indrawing of the lower spaces on inspiration. Goodhart[34] and D'Arcy Power[35] while admitting the the bulging, state that in fairly long standing cases, there is usually retraction and falling in of the chest on the affected side. D'Arcy Power[36] says further that one sees lateral curvature of the spine, the concavity of the spinal curve being directed towards the affected side. The angles of the ribs are flattened, those on the sound side becoming more acute. There is also some slight rotation of the vertebral bodies.

There may be localised bulging indicative of pus pointing. This is quite diagnostic of an empyema, as a simple serous effusion never points. The usual site for the external rupture of an empyema is anteriorly close to the sternum from the 3rd to the 6th spaces. It is seldom now-a-days that the condition remains so long unrecognised that pointing has time to occur; hence this is a sign of little clinical import.

Palpation: In many cases, though certainly more commonly in those of long standing, the skin becomes very harsh and dry. This may be seen in any illness which produces wasting, and consequent loss of nutrition of the skin. However, in such cases there is, at the same time, a loss of elasticity which is not always present in the case of an empyema, and certainly this harshness is seldom seen in a simple effusion, and for this reason is often helpful when present. Oedema of the chest wall is also referred to by several writers. This sign I have never been able to elicit in any of my cases, though I have always examined carefully for it.

Carmichael[37] lays considerable stress on it. On the other hand, Lindsay[38] though acknowledging it, points out that it is very fallacious.

Some authors hold it possible to obtain fluctuation between the interspaces, but fluid present in such large amount as to give this phenomenon would be so evident otherwise that it greatly minimises the diagnostic value of this sign.

Palpation helps one to ascertain the position of some of the various organs in relation to the pleura which by an alteration of their normal position indicate the presence of fluid in the pleural cavity. These organs are the heart, the spleen,

and the liver. Of the above perhaps the heart is the most important. The determining factor of the position of the heart is the apex beat.

In a left-sided effusion the apex beat is pushed over to the right, and may lie right behind the sternum. It may be impossible to ascertain this by palpation. So one has to fall back on percussion, or better auscultation to determine it.

A left-sided pneumonia which is not clearing up, and in which the apex beat is gradually being displaced to the right is almost diaghostic of an empyema.

Dawson Williams[39] attaches great importance to cardiac displacement. Rotch[40] D'Arcy Power[41] and Koplik[42] do not consider it of very frequent occurrence, unless the effusion be large. In almost 50% of my cases the heart's apex was displaced from the normal.

The fallacies of this sign are seen in cases of fibroid phthisis and old pleurisies which form adhesions and pull the heart from its normal position.

The liver, if the effusion be right-sided, and the spleen, if the fluid be on the left side, may be displaced downwards; but as Rotch points out, only where the effusion is so large and evident that this can hardly be of any value as an early guide to diagnosis.

Vocal fremitus is of so little clinical value in children that any alteration is seldom of interest, though one may detect marked diminution over the side containing the fluid.

Mensuration: Little is to be gained by the use of the tape measure, but in children where the softness of the bony elements of the chest wall permits of their adaptation to increase of content a cyrtometer tracing shews a change of shape from the normal elliptical to a more circular outline.

Percussion: One usually gets dulness over the site of the effusion. It may be only impairment or it may be absolutely dull, imparting a sense of resistance to the finger like that obtained on percussion of stone.

Above the level of the fluid one may frequently obtain a markedly hyper-resonant note.

The level of the dulness is of importance in distinguishing from consolidation, to which I shall refer later in considering the differential diagnosis.

Auscultation: Fluid in the pleura gives almost any variety of breath sounds and vocal resonance. One may find the usual sounds as in the adult, viz., diminution or loss of breath sounds and vocal reson-

ance, but on the other hand, the breath sounds may be tubular, with little or no modification of vocal resonance.

Goodhart[43] points out that bronchial breathing above the level of the fluid is quite common, and further one may hear exaggerated breath sounds on the other side. As a general rule there are no accompaniments, though care must be taken to try and eliminate any conducted sounds. It is in the localised empyemas that the difficulties of diagnosis are multiplied tenfold.

Brothers[44] puts it that the absence of râles in a child who otherwise presents symptoms of chronic lung disease is very suggestive; and if râles are heard all over the chest except at a single spot, then probably one is dealing with a localised empyema.

The vocal resonance at the upper limit of dulness may have an aegophonic twang. On the whole, however, the auscultatory phenomena are so varied as to make them very unreliable factors in diagnosis.

Temperature: The belief that pus in the pleural cavity must necessarily give rise to an elevation of temperature is quite fallacious.

In almost a third of my cases there was no rise above the normal, and in none was the temperature about 103°F. This fact is supported by many

authorities. Rotch[45] says there is nothing in the temperature. Goodhart[46] holds that though normal through the day, there may be remissions of temperature during the night. He also states that the temperature is of great value in registering a re-accumulation of pus after an operation for its removal. Any slight accumulation of pus immediately affects the temperature. This, he considers, a very delicate reaction.

Henoch[47] refers to a persistence of fever with evening exacerbations with emaciation and loss of strength as strongly indicative of empyema. At the same time, he acknowledges the fallacy and as does Lindsay[48] warns one not to lay too much stress on any absence of temperature as negativing the possibility of a purulent effusion.

Leucocytosis: In all doubtful cases considerable aid may be obtained from an examination of the blood, chiefly with reference to an increase in the white blood corpuscles. In an inflammation of lung substance or pleura, there is always a reaction in the blood constituents, resulting in an increase of the polymorphonuclear leucocytes. But a purulent reaction to the irritant always gives a much greater increase in the leucocytes. In only two of my cases was an examination for leucocytosis

conducted. In the one 28,000 and in the other 30,000 leucocytes were estimated per c.m.m. Care must be taken to exclude the digestive leucocytosis which in children is more marked than in the adult, giving as high as 20,000 white blood corpuscles after a meal.

Generally speaking, I should say that anything above 25,000 per c.m.m. is indicative of pus.

Koplik[49] and Holt[50] mention the occurrence of a leucocytosis, but do not attach to it that importance which I think it deserves.

Glycogenic Reaction: This reaction also takes place in the blood and is described by Gulland[51]. It consists in staining a blood film with a solution of Iodine and Potassium Iodide, which gives a characteristic reaction in the polymorphonuclear neutrophile leucocytes due to the presence of glycogen in the cell stroma. The nucleus is not affected. The glycogen is stained a brown or reddish-brown colour. The cells affected may show this colour reaction as either

1. A diffuse colouration.
2. As fine granules scattered through whole or part of the cell body.
3. As coarser granules or masses which may be scattered through the cell body, but are usually found at or near the periphery, sometimes indeed projecting as pseudopodia from it.

In a well marked case this last form is the most commonly seen, and the two preceding forms in less well marked cases.

In the hands of a skilled and experienced observer this sign is of considerable importance, but one requires to have studied the microscopical characters of the blood for a considerable time before one can speak with any degree of confidence on this reaction.

Gulland claims that in empyema it is always very well marked, and that it is of great value as a differential diagnosis from serous effusions in which as in pneumonias after the crisis it is negative.

Rontgen Rays: Within the last few years the X-rays have been called into play as an aid to diagnosis. They are of value chiefly in distinguishing fluid dulness from that of consolidation, and also for corroboration of displacement of viscera.

The following points should be noted in screening a thorax:-

1. The amount of movement of the diaphragm.

Almost invariably that side of the diaphragm which is in relation to the pus does not move at all, indeed, it may be considerably depressed. At the same time, however, one must remember that in any acute lung condition, the diaphragm does not show much mobility.

2. The Character of the Shadow:

Fluid gives a definite shadow since it refuses transmission of the rays. The shadow is usually less pronounced superiorly, and more marked as it nears the base. Changes in the level of the dulness on change of position can be noted more reliably than by percussion. This phenomenon can only be observed when there are no adhesions to interfere with the mobility of the fluid.

3. Displacement of Viscera:

The screen is of particular value in ascertaining the position of the heart. Percussion may give one a false conception of the cardiac dulness, due to thickened pleura, etc. interfering with the normal resonance. This is overcome by the X-rays. Displacement of the liver and spleen can usually be detected by palpation, but the rays always supply corroboration.

The literature on the diagnostic value of the X-rays in empyema is somewhat meagre. Williams(52) and Walsh(53) also note the gradual deepening of the shadow from the upper limit of the fluid to the base. Green(54) reports a case of pyo-pneumo thorax with change of position of the upper level of the shadow consequent on change of position of the patient.

Walsham[55] reports a similar observation and further holds that he can detect in some cases a ripple transmitted across the upper limit of the dulness by the systole and diastole of the heart, or by percussing the chest wall.

In one of my cases this change of the level of the fluid with change of the patient's position was exceedingly well demonstrated by the X-rays.

Before discussing the really only absolutely certain diagnostic of pus, namely, exploration, let me quote the following extract from Hippocrates[56] in which attention is drawn to several of the above-mentioned points, and is of no small interest as a proof of the accuracy of the observations of the ancient physicians.

> "If empyema be only on either side, one should turn him, and inquire if he has pain on the other side, and if the one side be better than the other and when laid upon the sound side one should inquire if he has the feeling of a weight hanging from above, for if so the empyema will be upon the opposite side to that on which the weight was felt.
>
> Empyema may be recognised in all cases by the following symptoms:

In the first place the fever does not go off, but is slight during the day and increases at night and copious sweats supervene. There is a desire to cough and the patients expectorate nothing worth mentioning. The eyes become hollow, the cheeks have red spots on them; the nails of the hands are bent, the fingers are not. especially the extremities. There are swellings in the feet. They have no desire of food and small blisters occur over the body. These symptoms attend chronic empyema and may be much trusted to; and such as are of short standing are indicated by the same provided they be accompanied by those signs which occur at the commencement, and if at the same time the patient has difficulty of breathing."

Paracentesis Thoracis: This is the only absolute and indubitable proof of pus in the pleural cavity. As a means of diagnosis it should always be employed whenever there is the slightest possibility of pus being present in the pleura. The operation is trivial in the extreme, and when conducted with care under ordinary antiseptic precautions, one might say is absolutely without risk.

For purposes of exploration a needle of fairly large calibre should be used, e.g. that for injecting

antitoxin. As a practical test one should be able to draw up oil through the needle into the bore of the syringe.

In exploring one should insert the needle at the point of greatest dulness. The skin having been cleaned and the needle sterilised, feel for the costal interspace and insert the needle with a quick push near the upper border of the lower rib to avoid wounding the intercostal artery, though I believe the danger of wounding the vessel is so slight as to make it almost negligible. To obviate going too far one should place one's finger on the needle about one inch from its point. D'Arcy Power[57] advocates incising the skin with a scalpel to avoid carrying flakes of epidermis on the point of the needle. This is unnecessary and only adds to the patient's discomfort and probably in consequence makes one hesitate repeating an attempt if at first unsuccessful. Goodhart[58] tabulates three risks of exploration, namely

1. Wounding the heart, if that organ be displaced.
2. Causing pneumothorax, or
3. Setting up surgical empyema.

The first one can only imagine occurring where ordinary care had not been taken to ascertain the position of the heart, and surely the amount of

fluid necessary to displace the heart to such an extent would be fairly evident, and on the opposite side to that of the cardiac displacement.

Pneumothorax I have never seen recorded after exploratory puncture and one cannot but believe that the lung substance must be punctured in numberless explorations without any such grave result. The natural elasticity of the lung tissue would close the almost infinitesmal puncture made by the needle and the same holds true of the thoracic wall in the case of surgical emphysema.

A positive result with the exploring syringe is of course final in the majority of cases, though it may be fallacious. To these fallacies I should like to draw attention.

1. An abscess in connection with necrosis of a rib or some similar condition may give a positive result.

The short history and the pointing of the abscess should apprehend one of its superficiality, as does also the tenderness over the rib on pressure.

2. Another possible source of error is an abscess in the lung substance itself. The following case in my series illustrates this fallacy and is also of great interest in that it shews cavity formation to an extent rarely seen in children.

F.H. Aet 6 years.

Admitted on the 9th January, 1904. One week's history of cough, with rigor and sickness at onset. On admission complained of pain in left side. Family and previous history negative. Child was slightly cyanosed. Respirations short and catchy. Fingers were suspiciously like clubbing.

Lungs: Dulness from the left scapular angle down to the base, and extending round into the axilla. Over this area the breath sounds, though diminished, were bronchial in type, with some increase of the vocal resonance, but no accompaniments.

Heart was not displaced.

13th January: Chest explored. Nil found.

16th January: Rib resected. Nil found.

30th January: Heart slightly displaced to the right. Some pleural friction at left base. The dulness is increasing upwards.

2nd February: Fingers clubbing. Breath sounds cavernous over left chest.

5th February: Evidence of consolidation on right side at base.

20th February: Chest sinking in on left side.

25th February: Tubercle bacillus found in the sputum.

March 8th: Apex beat displaced to the right.

11th March: X-rays confirm cardiac displacement and deposit in right lung.

15th March: Chest explored on the left side and pus found. 6th rib resected in anterior axillary line, and a quantity of thick pus evacuated.

April 20th: Slight haemoptysis.

April 24th: Meningeal symptoms set in, tremors of limbs, spasm, coma and death.

P.M. Showed tuberculous meningitis. Left lung densely adherent to chest. The empyema wound leads into a large cavity, ragged and occupying the whole of the lower lobe. Depending into this cavity is a ramifying network representing bronchi and blood vessels. All the lung tissue has gone. The inner wall is caseous and necrotic.

Right lung shows a few tuberculous deposits, mesenteric glands also enlarged.

3. A positive result may be obtained from tapping a dilated bronchus, as in bronchiectasis. A case occurred under my own observation which I am inclined to think comes into this category. The child was admitted with a five week's history of wasting. The fingers were clubbed. There was dulness at the right base which gradually increased. The chest was explored and pus found capsulated

diplococci resembling pneumococci. No tubercle bacilli were found. The white blood corpuscles numbered 16,000 per c.m.m. A rib was resected and nothing found. The visceral and parietal pleurae were very adherent and the lung tough and leathery, but expanding well. The wound healed by first intention, and the child improved greatly in general health. The X-rays showed several patchy deposits in the left lung.

On the other hand, a negative result is not conclusive and one should never be satisfied with a single fruitless exploration, if the physical signs are strongly suggestive of fluid. The pus may be too thick to run through the needle.

One may penetrate the lung substance and so miss the pus, but although Jacobi(59) calls attention to this possible source of error, one could hardly conceive of the needle being withdrawn without some few beads of pus being sucked into it which could be demonstrated under the microscope. Another source of error might arise from the needle being blunt and pushing before it a rather tough and thickened pleura. This is one of the reasons for making one's puncture with a fairly quick thrust. There may be large gelatinous masses floating in the fluid which block the point of the needle.

The following case in my series illustrates this last fallacy:

A.P. Aet 1 8/12 years, came into hospital with a history of pneumonia six weeks previously and cough and loss of appetite since.

He was admitted January 1904. There was marked dulness over the right base posteriorly, which area was explored on several occasions without result. He subsequently developed a patch on his tonsil and eventually died suddenly, though bacteriologically the swab culture of the throat did not show the Klebs Loeffler bacillus.

At the post mortem examination there were found large gelatinous masses floating in 6-8 oz. of turbid fluid at the right base, with tracks of the needle showing through into the pleura, proving that the needle had been inserted into the fluid. The fluid was pneumococcal.

Jacobi(60) also points out that if the patient be in the erect posture when the needle is inserted, the pus cells, bacteria, etc., may have gravitated to the bottom of the fluid, and only clear serum be withdrawn. One cannot but think that the patient would require to maintain the erect posture for a considerable number of hours for this to take place,

as one can usually find pus cells in the superficial portion of a purulent exudate, even after standing several hours in a glass vessel.

On the other hand, Prudden[61] holds that one may find the tubercle bacillus, or even the pneumococcus, in an exudate not necessarily purulent. In the case of the pneumococcus one would be surprised if any growth took place after inoculation on a culture medium.

Levy [62] gives this axiom - that in the withdrawal of a purulent exudate which does not give any organism either from a smear or a culture, suspect tubercle.

The prognostic value of exploration and its indication as to treatment will be referred to later on.

Despite the failure to obtain pus after our exploration, one should not rest satisfied, but should repeat the operation several times, varying the site of puncture and even then the risk of incision or resection of a portion of a rib, is not of such gravity as to contra-indicate its being done, should one have a very strong belief that pus is present. Certainly the fact that pus has been missed is a much more serious error from the patient's point of view than a negative exploratory incision.

TREATMENT:

This is one of those diseases where nature registers but few successes. At the present time whenever and wherever pus is diagnosed, it is removed by operative measures of some sort.

If the condition be left alone, there are many possibilities of a cure, but the process is too exhausting for even the strongest constitution, so that masterly inactivity in the case of an empyema cannot be too strongly condemned. If left alone:-

1. The pus may become absorbed. Several cases have been recorded where in the course of a P.M. conducted on one who has died from a separate and definite cause, some calcareous matter has been found in the pleural cavity, indicative of pus undergoing calcareous degeneration.

2. The pus may find its way externally:-

(a) By perforating the chest wall. As already pointed out, the perforation usually takes place about the region of the nipple.

(b) By burrowing down along the spine simulating a psoas abscess. It may set up general peritonitis by bursting into the general peritoneal cavity through the diaphragm.

(c) By bursting through the lung substance and being expectorated through the medium of the bronchi.

Hippocrates(63) found this mode of termination quite common and held that if an empyema discharged

through a bronchus within 30 days after the onset of the illness, the patient was saved. Also that this was more favourable than an evacuation by external rupture.

Littre[64] commenting on this concludes that Hippocrates must have been including cases of phthisis which were also called empyema by the ancients, or else the paucity of such cases now-a-days is due to the present surgical treatment which in those early times was but seldom employed.

Schmidt[65] has reported 19 cases of spontaneous evacuation. Of these 17 died and two recovered.

The undernoted case in my series seems to correspond with such a mode of termination.

H. aet 2 years. A boy, rather poorly nourished. Two months previous to admission on 7th December 1903, had had bronchitis. Two days before admission had become drowsy, and cough started, gradual wasting.

Over the right scapular angle the percussion note was impaired. The breath sounds were tubular, some increase also of the vocal resonance.

10th December: Dulness was increasing.

14th December: Pus was coughed up, about ʒiss

1st January: Dulness still marked, so a rib was resected, but nothing found.

3rd January: Dulness was clearing up.

21st January: Was dismissed cured.

That evacuation of the pus is absolutely necessary for recovery is acknowledged by all, but the special means for bringing about such a result is a matter which has given rise to much controversy.

The following methods have been adopted.

1. Aspiration only.
2. Aspiration with washing out of the pleural cavity.
3. Simple incision.
4. Rib resection.
5. Estlanders operation.

Aspiration: It is quite an established fact that an empyema can be cured by aspiration. Holt(66) quotes 25 cases cured by the use of this method only. I have had under my care one patient with a double empyema where one side was evidently cured by two aspirations.

Koplik(67) and Jacobi(68) maintain that aspiration is not sufficient and certainly in the majority of cases it is not.

Some cases, however, are more favourable than others for aspiration, depending mainly on the specific organism found in the pus and the nature of the empyema.

Sinclair[69], though admitting that aspiration is not the ideal cure,holds that in pneumococcal cases repeated aspiration may be successful. The pus in the case referred to in my own series was of pneumococcal origin.

Barbour[70] also believes that aspiration is often all that is necessary.

A favourable termination is more likely to result when the empyema is small and locculated.

Coutts[71], Ashby[72], Wright Heaton[73] and others corroborate this though not advocating it.

In some instances there is no option on account of the weakness of the child and its consequent inability to stand a major operation.

Most are agreed that aspiration is not a method to be persevered with.

Holt[74], D'Arcy Power[75], Donkin[76] and Rotch[77] say once and once only. Many say not more than twice. On the other hand Lane[78] advises early and frequent aspiration. Some believe in it as a routine before performing the major operation. This is unnecessary unless the condition of the child does not warrant the more serious step at the onset.

Again in those cases of double fluid effusions where the mechanical obstruction to respiration is

exhausting the child, aspiration should be done on the one side and either incision or resection on the other. If possible several days should elapse before the more severe operation is performed on the aspirated side. Coupland[79] and Pearce Gould give out this dictum that in double empyema one should let a couple of days elapse between each operation on either side of the chest. If delay be impossible, aspirate a few hours before the operation first on the one side and then on the other.

Koplik[80] also upholds this method.

Aspiration with injection of fluid with a view to destroying the organisms is a method seldom, indeed if ever, used nowadays. The chief objections are the large absorbing surface presented by the pleura, and the risk of the sudden introduction of fluid causing syncope. The paucity of beneficial results is also against its adoption as a good and efficient means of cure.

The only author who takes notice of this method that I can find is Coutts[81] who merely mentions it as one of the methods employed in treatment.

Simple incision: This means evacuation of the pus by means of a drainage tube inserted through an opening in an interspace made by a simple incision and without in any way interfering with the bony

or cartilaginous framework of the thorax.

In a non-localised general empyema, the incision is usually made between the 7th and 8th ribs in the posterior axillary line. In a loculated case, one would incise in the most dependent part, taking care on the right side of going too low for fear of the diaphragm and on the left of going too far forward and injuring the pericardium.

The length of the incision should never be under one inch.

On reaching the pleura, one should perforate it with a pair of sinus or dressing forceps evacuating the pus after Hilton's method of opening an abscess. Then insert the drainage tube which should be as wide as possible, though not necessarily long,and secure it from slipping into the pleural cavity, by means of a phlange, or quite a good method is to transfix the tube with a sterilised safety pin. It is better not to evacuate all the pus at once, but rather to let out about one half and allow the residue to soak gradually through the dressings.

Pollard(82) has brought out a special tube, with a double phlange, which answers very well in adults, but which I have never had the opportunity of using or seeing used in children. The advant-

ages claimed for this method are:-

1. The rapidity with which the operation can be performed.

2. That a general anaesthetic is not required, a local anaesthesia answering the purpose quite well.

3. Consequently from the above two reasons, the shock is less.

4. There is less danger of pyemia resulting; for one does not interfere with the bone as in resection and leave open medullary canals as a means of spreading infection. Though this seldom occurs in resection, there is always the off-chance, and the means of spreading the infection.

5. The drainage is quite efficient.

Resection: This method entails the removal of a piece of rib. The rib usually selected is either the 7th or 8th about the posterior axillary line. Make an incision 2 inches long over the rib, going right down to the bone. Strip off the periostium both anteriorly and posteriorly with an elevator, and having bared the bone, snip it through with a pair of ordinary bone forceps or Estlander's pair, specially designed for the purpose. Remove a portion of rib about one inch long. Then, as in simple incision, go through the pleura and insert a drainage tube.

The advantages claimed for this method are:-

1. Thorough drainage.
2. That the finger can be inserted and adhesions broken down, and that an idea can thus be obtained of the underlying lung substance. Koplik[83], however, strongly condemns this, saying that by so doing, one often breaks down nature's protecting barriers and thus makes the purulent infection more general.
3. That there is every chance of controlling haemorrhage.
4. That there is less pain in subsequent dressings than in incision.
5. That recovery is more speedy than in simple incision.

Contrasting these methods: Incision undoubtedly causes less shock and hence is of great use in very young or debilitated children. The risk of haemorrhage and imperfect drainage are imputed disadvantages. The former may be discounted,as the blood vessels are so well protected by the ribs and the exercise of a little caution nullifies this risk.

As regards drainage,it is only in very deformed chests that an interspace cannot admit a sufficiently large tube to quite efficiently evacuate the pus. Further, should the drainage be insufficient, it is

quite an easy matter to remove a portion of the rib through the primary incision.

Resection cannot be satisfactorily performed without a general anaesthetic. This in itself introduces an element of danger quite apart from the empyema and on considering this added risk, one hesitates about taking such a responsibility.

Wightman(84), however, does not consider that chloroform is contraindicated in empyema.

Dowd(85) again advocates a slight ether anaesthesia.

That there is less pain during subsequent dressing after resection, I should be inclined to doubt very much. I have always found it quite as easy to reintroduce the tube through a simple incision as through a resection. To my mind, children resented the one quite as much as the other. The contention that recovery is more speedy after resection is borne out to some extent by the statistics of various observers.

Cautley(86) puts recovery at nine weeks in incised cases and seven weeks in resected cases.

Coutts(87) found that the average stay in Hospital of the incised cases was $3\frac{1}{2}$ months, while that of the resected was only $5\frac{1}{2}$ weeks. Holt(88) puts the incised cases at 5 weeks, Batten(89) the

resected at six weeks.

In the cases under my own care, I found that the average stay of the incised was 7 weeks, while that of the resected was 5½ weeks. The most rapid recovery occupied three weeks under both methods of treatment. The longest recovery of the incised cases occupied ten weeks, of the resected 8½ weeks.

To my mind, this discrepancy in time, like all others, between the two methods of treatment, rests on the fact that it is usually only on the very young and debilitated children, where resection is contraindicated, that one performs the operation of simple incision; and consequently the convalescence is more protracted, due to the inferior recuperative powers of the patient.

Statistics and tables without end have been compiled to show the relative merits of the two methods.

Coutts[90] gives a death rate of 37% in cases treated by incision, and of 11% in those by resection. This statement, however, he qualifies by stating that his statistics for incised cases were compiled at a much earlier date than were those for cases of resection. Surgeons were more chary of entering the thorax, and the empyema was longer in being diagnosed, and consequently his statistics

hardly give one a fair idea of the relative fatality. He further states that in one Children's Hospital in London, 87 consecutive cases were treated by incision with only one fatality.

Cautley[91] puts the incised at 20% and the resected at 18.2%. Blaker[92] quotes a mortality of 54% in incised cases, but in all of these, there was secondary septic infection elsewhere, chiefly in pericardium or meninges.

Batten[93] gives 11% as the death rate from resection, while Scharlau[94] puts it at 33%.

These statistics, all from reliable sources, show the diversity of opinion that exists amongst the various writers on this subject. In my own series 25% died after incision, and 36% after resection. It would be folly, however, to base one's treatment on statistics alone. There are many factors which must of necessity be taken into consideration in each individual case, e.g. the age of the child, and consequently its power of resistance to the shock of an operation, and also the nature of the empyema.

With regard to the influence of age upon the method of treatment, Winters[95] gives a death rate of 80% under two years of age from resection.

Blaker[96] had one recovery out of eleven cases under one year of age.

Cautley[97] found that in children under two years, there was a mortality of 25% from incision, but of 80% from resection, the latter percentage gradually diminishing up to the 5th year, when it became 25%. In my own series, I had seven cases under two years. Of these, three were treated by incision, and all recovered, four were treated by resection, and one died. After a careful study of all these statistics and tables, one is almost forced to adopt a middle course. I would suggest that simple incision should be performed in all children under two years of age and in those of two years onwards, where excision was contraindicated contraindications arise in the shape of:-

1. Severe dyspnoea.
2. Marked displacement of the heart and a resulting feeble pulse.
3. Any valvular lesion of the heart.
4. A double empyema.

Koplik[98] puts the age limit for incision at 18 months. Amongst many others Ashby, Wright, Coutts, Goodhart, Wightman, Carmichael, Holt, Barbour and Blaker accept the above suggestion with a leaning towards incision in as many cases as possible. On the other hand, Dowd, Rotch, Sinclair

and D'Arcy Power advocate resection wherever possible, while Henoch, Donkin and Batten hold out for resection in all cases. Still, despite all conflicting evidence, both for and against the two methods, one cannot help feeling that a middle course is the wiser, the safer and more rational one to adopt.

After treatment: This is a matter very frequently overlooked by many writers, but it is none the less important on that account. There are several things to be considered which require one's careful consideration and attention, as they influence not only convalescence, but even recovery. These are:-

1. The removal of the tube.
2. The washing out of the pleural cavity.
3. The aids to re-expansion of the lung.

Naturally general hygiene must be observed. The diet should be as generous and as nourishing as possible in accordance with the child's age. By the removal of the tube I mean the time for dispensing with a drainage tube altogether. Writers, as a rule, are very vague about this. The early removal of the tube means quicker healing of the wound and minimises the risk of a sinus forming.

Holt[99] and Goodhart[100] support this early removal, the former giving as an average the 10th to the 14th day. Of course, one cannot hold definitely to any set time as the circumstances of each individual case introduce modifications. As an indication for the tube's removal, I would consider the following, viz. When the discharge becomes very slight, and then chiefly serous, one is often misled by a discharge due to mechanical irritation set up by the tube, which ceases on the removal of the cause. Personally I have removed the tube as early as the fifth day without any untoward result. If after removal of the tube the temperature should rise, which rise is unaccountable by any other reason than a re-accumulation of pus, then the tube can be reinserted without much trouble. Another indication of re-accumulation is steady loss of weight, as pointed out by Thomson[101].

I strongly advocate early removal of the drainage tube.

With regard to the washing out of the pleural cavity, Hippocrates employed this as a routine in his resection cases, using for the purpose a mixture of wine and oil. The concensus of opinion, in fact the almost universal opinion, is that it is a mistake to wash out the pleural cavity unless the

discharge is markedly foetid. The risk of washing out according to Goodhart[102] and Gwynne[103] is syncope. The danger does not lie so much in the amount of fluid used as in its rapid introduction. The thorax can fairly comfortably accomodate a large amount of fluid if gradually accumulated. But the thoracic organs have not time to accustom themselves, so to speak, to a fluid suddenly poured into the thorax, causing increase of pressure and probably cardiac displacement which brings about the fatal result. Should one have to resort to irrigation, I would advise a solution of Iodine (3i to the pint). This solution I found of great service in those cases requiring irrigation.

Aids to re-expansion of the lung: Koenig[104] says that if the incision be in the most dependent part, the patient should be horizontal with the hips raised and should cough as hard as possible for a short time three times a day. The effort of coughing causes the lung to expand and thus at the same time empties the pleura more thoroughly.

Any forced expiratory effort helps. In young children blowing trumpets; in children with sufficient understanding, the blowing of soap bubbles or of coloured water from one jar to another gradually raising the receiving jar, and thus in-

creasing the resistance, should be encouraged.

Estlander's operation: This consists in the removal of several portions of ribs. This is necessary when the cavity refuses to become obliterated. The removal of a portion of the bony framework of the chest enables the soft parts to fall in and thus fill up the existing cavity. The chest walls of children, however, are, as a rule, so elastic that an Estlander has seldom to be performed, and consequently we need not discuss it. Occasionally the terminal portion of the cut end of the rib necroses and a sinus results, which refuses to close. The treatment, in such a case, is to cut down and remove the necrosed portion and the sinus soon closes. Dowd[105] gives a sinus four months to close, but if still discharging at the end of that period, he advises operation. I think that one is justified in operating sooner were one convinced by probing that necrosis had set in. Other methods of treatment have been employed, e.g. puncturing the chest wall with a trocar and canula and allowing the fluid to siphon off through a long drainage tube with or without a valve at the end, leading into an antiseptic fluid. This method is hardly practicable in

children who would be too restless to maintain the one position necessary for the efficacy of the drainage.

Van Hook[106] reports two cases treated after the method of George Perthes. This consists in connecting a drainage tube cemented in an air tight manner to the opening in the thoracic wall with a jar whose pressure is kept below that in the thorax by a Bunsens air pump.

The one case was a chronic one and the other acute, both of which he states recovered completely. The difficulty in children is as stated above, the inability to remain in the one position. Another difficulty one would imagine would be the hermetic sealing of the tube into the thorax.

Differential diagnosis: Those thoracic lesions which most closely simulate empyema are:-

1. Pleurisy with effusion.
2. Unresolved pneumonia or chronic broncho pneumonia.
3. Abscess of the lung.

In a pleurisy with effusion the fluid is usually generally distributed so that any loculated collection of fluid is in favour of pus.

Taking the history into consideration, the knowledge of a preceding pneumonia is very strong evidence in favour of the fluid being purulent.

A blood examination both with regard to leucocytosis and the glycogenic reaction is of value more especially the former, as one seldom sees such a marked increase of white blood corpuscles in a simple serous effusion as in an empyema.

The age of the child is of some value; as a general rule the younger the child the more chance there is of the fluid being pus. Rotch (107) says that if there be no change in the fluid after a week or ten days one may reasonably expect to find pus.

As mentioned above the exploring needle is as a rule absolutely diagnostic.

In lobar consolidation of the lung one finds the dulness corresponding to the limits of the lobe involved, whereas in fluid the outline is more generally of a curved character with the summit of the curve towards the axilla and a fall towards the sternum. There is also no change of the level of dulness on change of position. Both of these facts can be confirmed by means of the X-rays. Further, in an X-ray screen of a pneumonia the shadow is uniformly dark, but in a fluid effusion it is lighter above and darker below.

With a pneumonia one often hears on auscultation the friction of the concurrent pleurisy, but

never does one get friction in an empyema.

Perhaps the greatest difficulty is experienced in eliminating a chronic broncho-pneumonia. Pearson[108] lays stress on the quality of the percussion note and the sense of resistance imparted to the finger. Otherwise he maintains it is quite impossible to distinguish a circumscribed empyema from a chronic broncho-pneumonia without using an exploring syringe.

From an abscess involving the major part of the lung the diagnosis is almost impossible even with the help of the needle, but the treatment employed is quite good in either case.

Holt[109] quotes a case of pulmonary tuberculosis with caseation of an entire lobe simulating the signs of a sacculated empyema. One of my cases already quoted also illustrates this.

The following case in my series is also of interest in this connection.

P.F. male, aet 1 1/12 years, was admitted to Hospital on the 2nd February 1904. There was a history of a sudden onset with convulsion seven days previously. Cough set in, loss of appetite and vomiting. On admission there was evident dyspnoea and cyanosis, also evidence of rickets.

The only system presenting abnormality was the respiratory system where there were signs of consolidation at the right apex.

On the 5th of February the temperature fell by crisis, but rose again on the 13th. On the 15th there was marked dulness from the right scapular angle down to the base. The breath sounds were vesicular in type with prolonged expiration accompanied by fine crepitations and slight increase of vocal resonance.

On the 18th the temperature came down and though the dulness persisted the crepitations were much coarser.

On the 24th breath sounds were quite clear, but percussion note was not good, though not definitely impaired.

On the 29th there was discovered marked dulness as high as the right scapular angle with diminution both of breath sounds and vocal resonance. There was no displacement of the apex beat.

On March 1st the chest was explored and pus found which on culture gave the staphylococcus pyogenes aureus.

On the 2nd of March simple incision was performed and about 3 viii of pus evacuated. Along with the pus a piece of substance was coughed out about $\frac{1}{2}$ cubic inch in size, which on microscopical

evidence turned out to be a portion of necrotic lung. The discharge, however, remained sweet.

During the next few weeks the ears started discharging. The organisms present in the discharge were mixed, but amongst others was the staphylococcus aureus .

The thoracic wound closed on the 28th of April and the child was dismissed cured on the 12th of May.

The only solution I can put forward is that the child had a pneumonia at the R.base and consequent on this an abscess formed. The lung tissue became necrotic towards the pleura and the abscess pointed and burst into the pleural cavity. Another point of interest is that in the ear discharge there should also have been present the staphylococcus aureus. It is more of a coincidence, I should think, than a general staphylococci infection.

Complications: In any disease constituted by a primary lesion of a purulent character, one is always liable to meet with secondarily infected foci in the various organs elsewhere. This is true of empyema. Naturally one would expect the pericardium to become involved from its close proximity to the primary infection, and such is

the case. One may find a simple inflammatory reaction in the pericardium or the reaction may go the length of pus formation. Similarly with the cerebral meninges and also, but more seldom, with the peritoneum.

In my own series there were three cases which post mortem showed complications. One had a purulent pericarditis, one had a peritonitis and one a combination of both the preceding complications.

Blaker[110] in a series of 22 post mortems conducted on cases of empyema found:-

Six with pyopercarditis.

One with pericarditis.

Eight with branchopneumonia.

Four with purulent meningitis.

Three with purulent peritonitis.

So far as I know there is no way of preventing this secondary infection. Should such complications arise and be diagnosed, they must be treated secundum artem. The diagnosis of purulent pericarditis is exceedingly difficult, and the treatment consists in opening the pericardium and draining it. Several cases of recovery have been recorded, but the percentage is not high.

The same holds good for the peritoneum.

Ashby, as quoted above, reports a case of recovery after operation for peritonitis where the micrococcus tetragenus was demonstrated on cultures taken from the peritoneal cavity.

In septic meningitis operative measures are of no avail and a fatal termination invariably ensues.

Prognosis: In a patient of good physique, over two years of age, where the diagnosis has been made early, the prognosis is quite favourable.

The chief factors to guide one in prognosis are:-

1. The bodily health of the patient.
2. The Age.
3. The nature of the empyema whether locculated or general as well as the specific organism producing the pus.
4. The presence or absence of complications.

The first need not be discussed as one's common sense tells one that the better the physique the more chance of a recovery.

With regard to the age, patients above two years run a better chance of a cure as shown above. The prognosis is better in a locculated empyema than in a general one and also where the infection is pneumococcal.

The presence of any of the above mentioned complications necessarily make the prognosis very grave, indeed almost render the case hopeless.

SUMMARY:

From the study of the literature on the subject, and from observations on cases under my own charge, I have made the following conclusions.

As aids to early diagnosis, other of course than paracentesis thoracis, one should where possible employ the X-rays and also an examination of the blood, both for a leucocytosis and the glycogenic reaction. Amongst the physical signs a combination of pleuritic look, clubbing of the digits and harshness of the skin is suggestive.

I hold that in any case with the least shadow of doubt one should explore by puncture the pleural cavity. Should the rsult be negative and still strong evidence of fluid exist, repeat the exploration several times and in different areas. Further, if still doubtful, explore by means of simple incision.

I also maintain that incision is to be preferred to resection and exclusively so in patients under two years of age. Above that age resection need only be resorted to if simple incision is not answering satisfactorily.

On no account should the pleural cavity be washed out without very strong indications arising.

For aforementioned reasons, I consider the early removal of the drainage tube a matter of considerable moment.

I have to thank Dr Eustace Smith, Dr Coutts and Dr Morley Fletcher, for their kind permission to publish the cases quoted throughout this paper, which cases were under my charge as House Physician to the East London Hospital for Children, Shadwell.

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